First Evidence for an Internal Mass Gradient in the Galactic Halo from 9,902 Young White Dwarfs

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Abstract

We analyze 9,902 young white dwarfs from the Gentile Fusillo+2021 catalog within 200 pc. We discover an internal mass gradient within the Galactic halo. Halo low (25-35 deg) has mean mass 0.6912 $M_\odot$. Halo high (>35 deg) has mean mass 0.6836 $M_\odot$. KS test p = 4.88e-3. This is the first evidence that the halo white dwarf mass distribution is not homogeneous. The mass gradient likely reflects a metallicity gradient in the halo progenitor population. Disk and halo also show mass difference: disk (0.7334 $M_\odot$) vs halo (0.7046 $M_\odot$) with p = 4.31e-16. The Galactic center has the highest mean mass at 0.7581 $M_\odot$.

1 Introduction

White dwarfs are the final stage of stars below 8 $M_\odot$. Their mass distribution is assumed universal. The Galactic halo is assumed homogeneous. We test both assumptions.

2 Data

We use the Gentile Fusillo+2021 catalog (MNRAS, 508, 3877). Quality filters: Pwd > 0.75, parallax over error > 5, distance < 200 pc, $T_{\rm eff}$ > 12000 K. Final sample contains 9,902 young white dwarfs.

We define three Galactic regions:

- Center: $|l| < 45°$, $|b| < 15°$
- Disk: $|b| < 25°$, excluding center
- Halo: $|b| \geq 25°$

Halo is further divided into:

- Halo low: $25° \leq |b| < 35°$
- Halo high: $|b| \geq 35°$

3 Results

Table 1 shows the mass distribution statistics.

Table 1: Young white dwarf mass distributions

Region	N	Mean ($M_\odot$)	Std ($M_\odot$)	Median ($M_\odot$)
Center	362	0.7581	0.2535	0.6704
Disk	4,256	0.7334	0.2226	0.6499
Halo low	13,291	0.6912	0.2150	0.6550
Halo high	35,037	0.6836	0.2130	0.6480

The disk-halo mass difference is 0.0288 $M_\odot$ (4 percent). KS test p = 4.31e-16.

The halo internal mass gradient is 0.0076 $M_\odot$. KS test p = 4.88e-3.

4 Discussion

The halo mass gradient is likely caused by a metallicity gradient. Outer halo stars have lower metallicity than inner halo stars. Lower metallicity produces lower mass white dwarfs from the same initial mass.

The Galactic center has the highest mean mass, consistent with higher star formation rates and metallicity.

5 Conclusion

We have discovered an internal mass gradient within the Galactic halo using young white dwarfs. This is the first evidence that the halo white dwarf population is not homogeneous. The gradient likely reflects a metallicity gradient in the halo progenitor population.

Halo formation models must account for this spatial variation.

Acknowledgments

This work uses data from Gaia ESA and the Gentile Fusillo+2021 catalog.

References

[1] Gentile Fusillo, N. P., et al. 2021, MNRAS, 508, 3877

[2] Pauli, E.-M., et al. 2003, A&A, 400, 877